

Our Energy Challenge: *The Role of Renewable Energy*

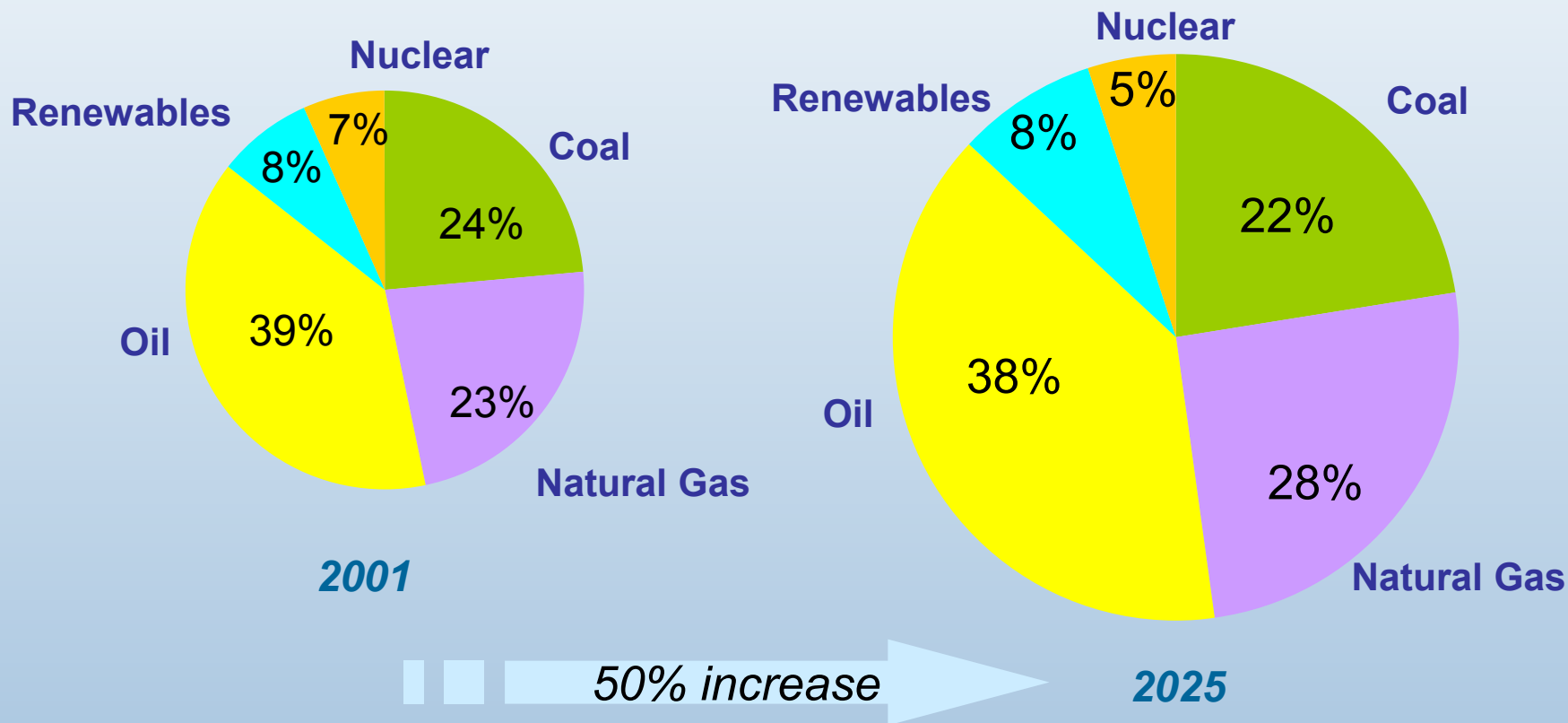
Renewables 2005
Turnberry Resort, Scotland

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Director, National Renewable Energy Laboratory

The Energy Challenge

- World energy demand will increase significantly
- World energy supply is mostly fossil-based and will remain so for decades
- Energy-related worldwide environmental impacts will continue to grow
- Access to affordable energy is not uniform

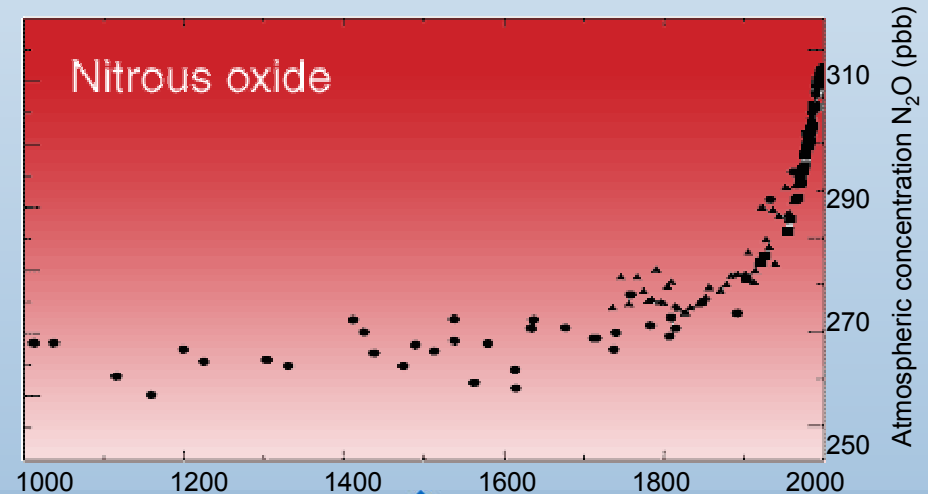
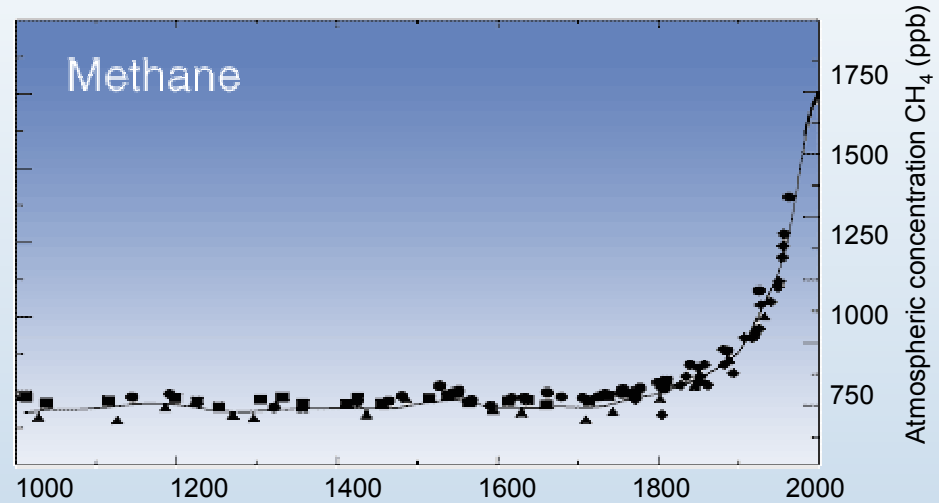
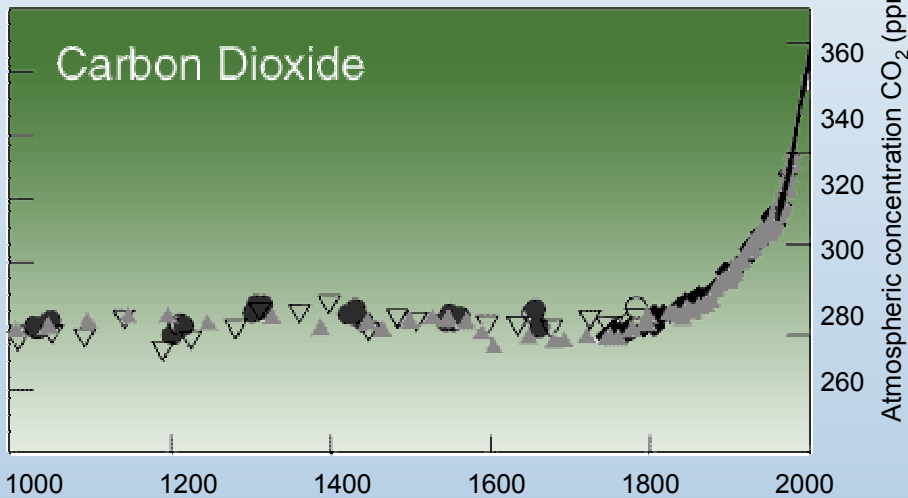
Worldwide Energy Consumption by Source



Changes in Atmospheric Concentration:

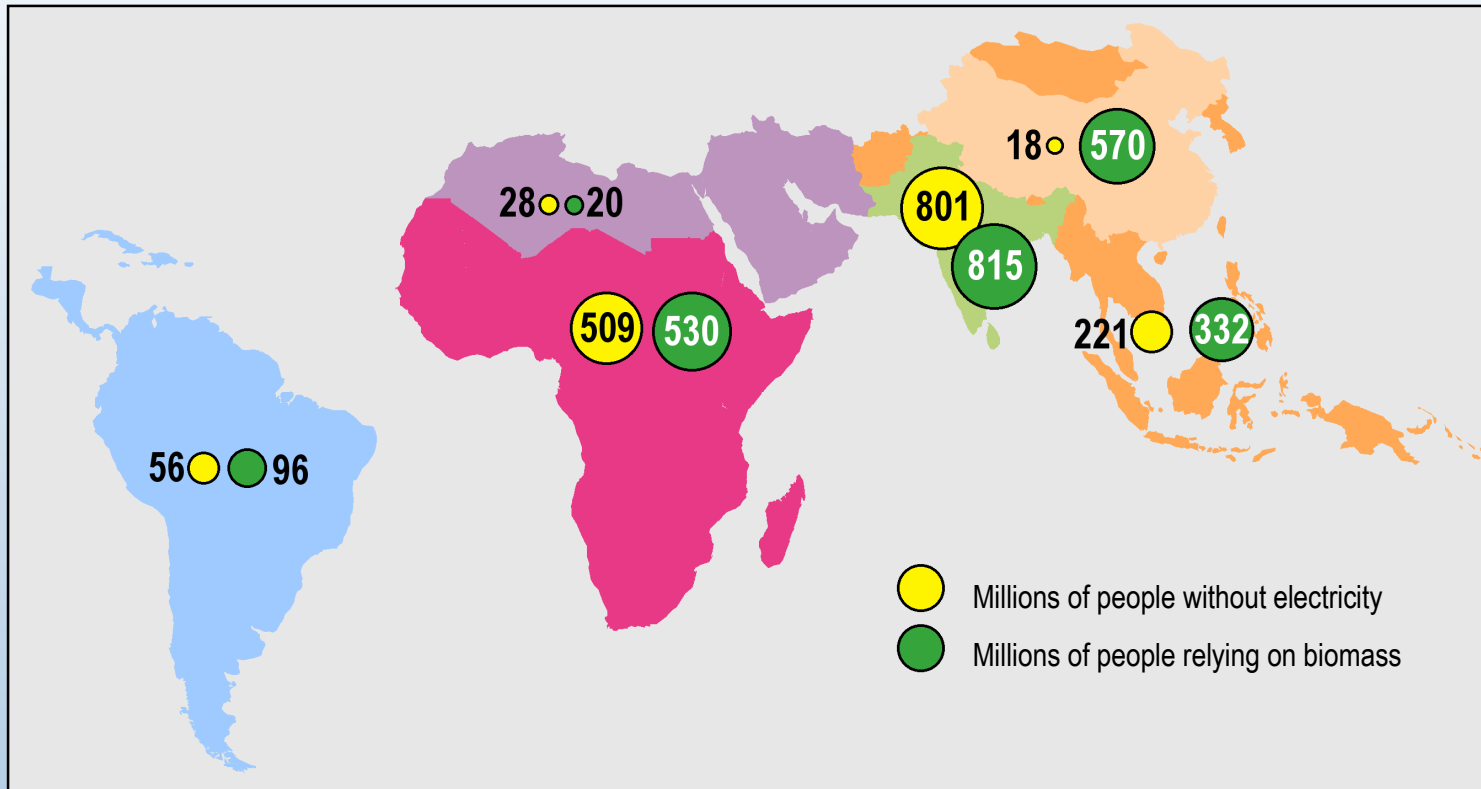
Recent trends are alarming

CO_2 , CH_4 , and N_2O
A Thousand Year History



Source: IPCC Third Assessment Report (2001)

Non-uniform Access to Affordable Energy: Implications for national security and social stability

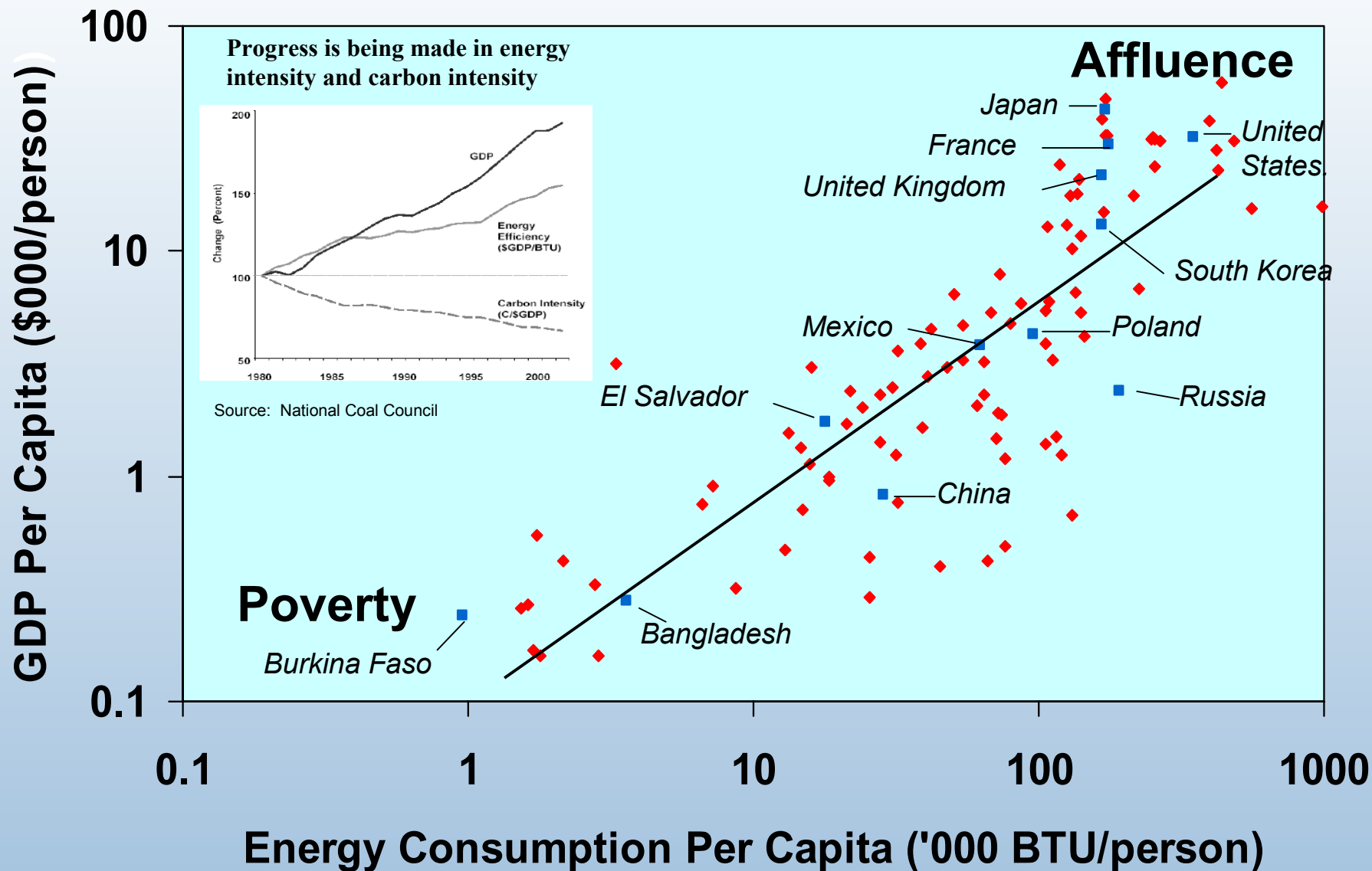


Map of global energy poverty

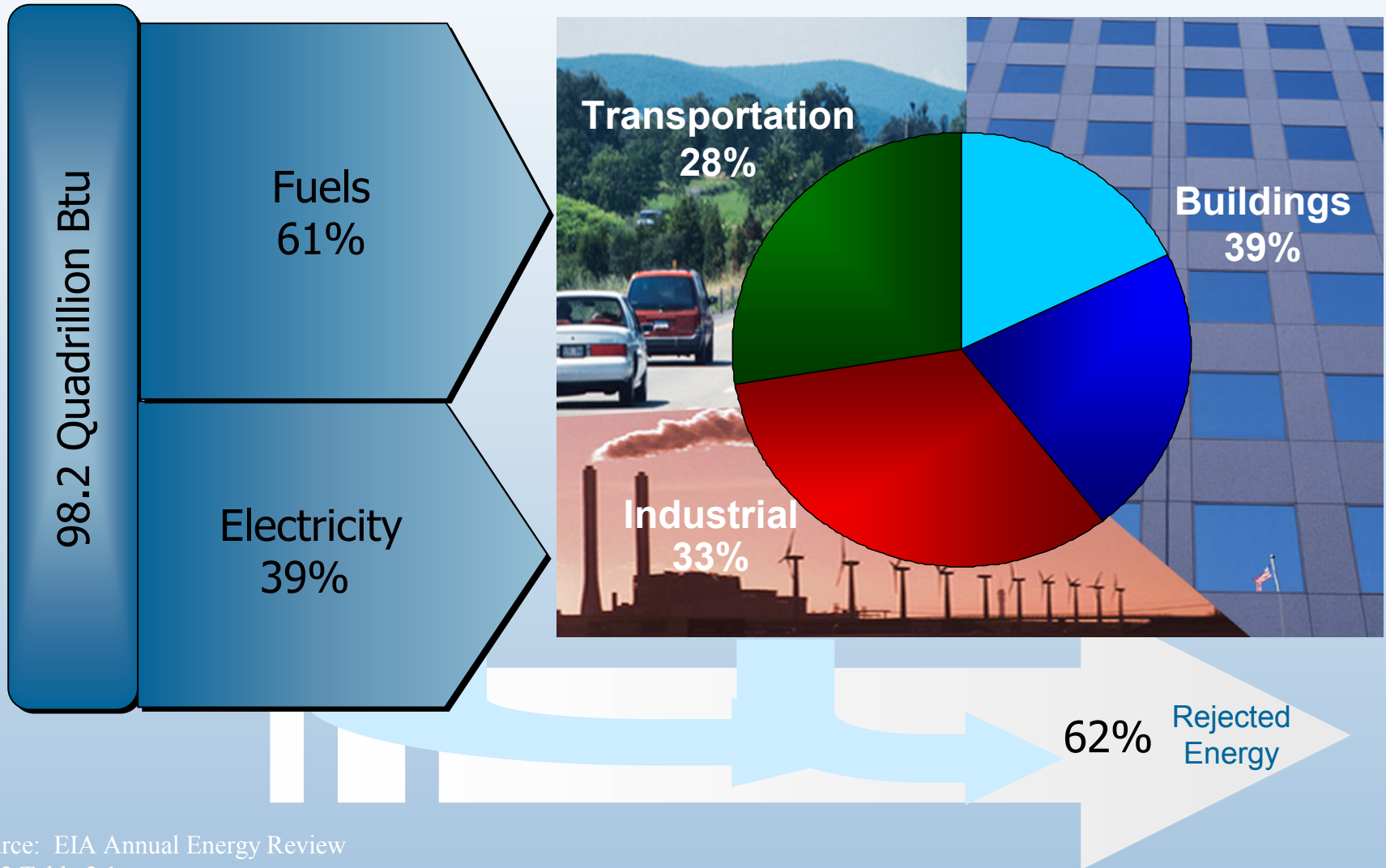
1.6 billion people have no access to electricity, 80% of them in South Asia and sub-Saharan Africa

Source: IEA World Energy Outlook 2002

Energy Use and Gross Domestic Product



U.S. Energy Flows



Source: EIA Annual Energy Review
2002 Table 2.1
Updated April 2004

How Can We Change the Energy Future?



Technology-based Solutions:

There is no one silver bullet, we need many

- Energy efficiency
- Renewable energy
- Non-polluting transportation fuels
- Separation and capture of CO₂ from fossil fuels
- Next generation of nuclear fission and fusion technology
- Transition to smart, resilient, distributed energy systems coupled with pollution-free energy carriers, e.g. hydrogen and electricity

Energy Efficiency & Renewable Energy Technology Development Programs

NREL R&D Portfolio

Renewable Resources

- Wind
- Solar
- Biomass
- Geothermal



Efficient Energy Use

- Vehicle Technologies
- Building Technologies
- Industrial Technologies



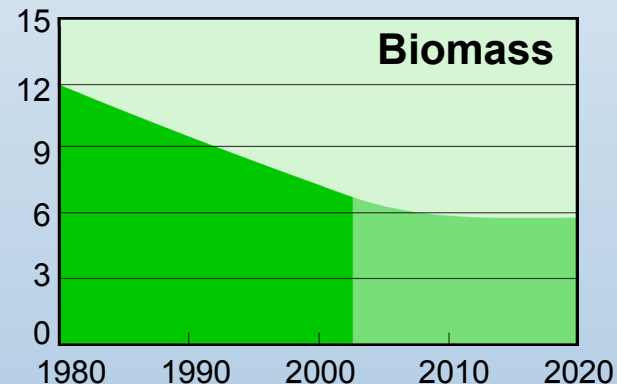
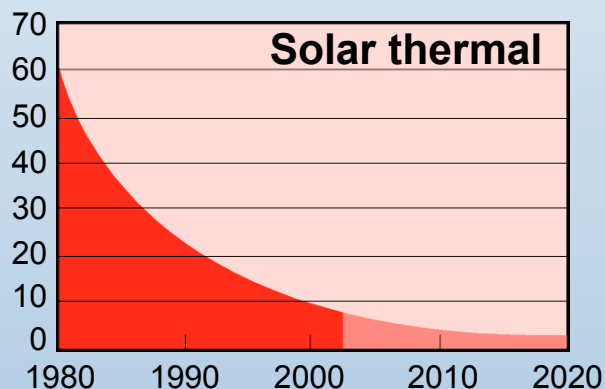
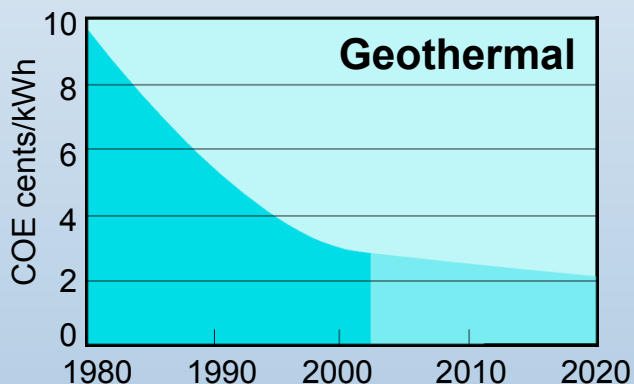
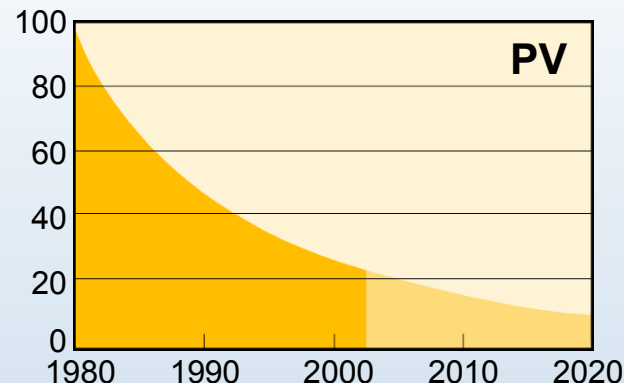
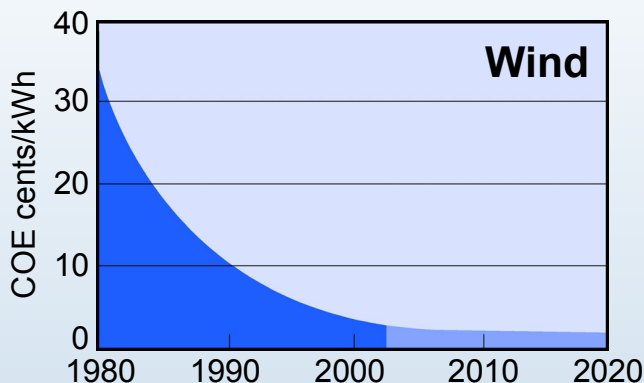
Energy Delivery & Storage

- Electricity Transmission & Distribution
- Alternative Fuels
- Hydrogen Delivery and Storage

Foundational Science

Renewable Energy Cost Trends

Levelized cents/kWh in constant \$2000¹



Source: NREL Energy Analysis Office (www.nrel.gov/analysis/docs/cost_curves_2002.ppt)

¹These graphs are reflections of historical cost trends NOT precise annual historical data.

Updated: October 2002

Research Focus in Solar

- Higher efficiency devices (cells, collectors, etc.)
- New nanomaterials applications
- Predictive solid-state theory
- Advanced manufacturing techniques
- Higher component reliability

Research Focus in Wind

- Low-windspeed turbines
- Advanced power electronics
- Better aerodynamic blades, new materials
- Technology transfer to ocean-based systems



Research Focus in Bioenergy

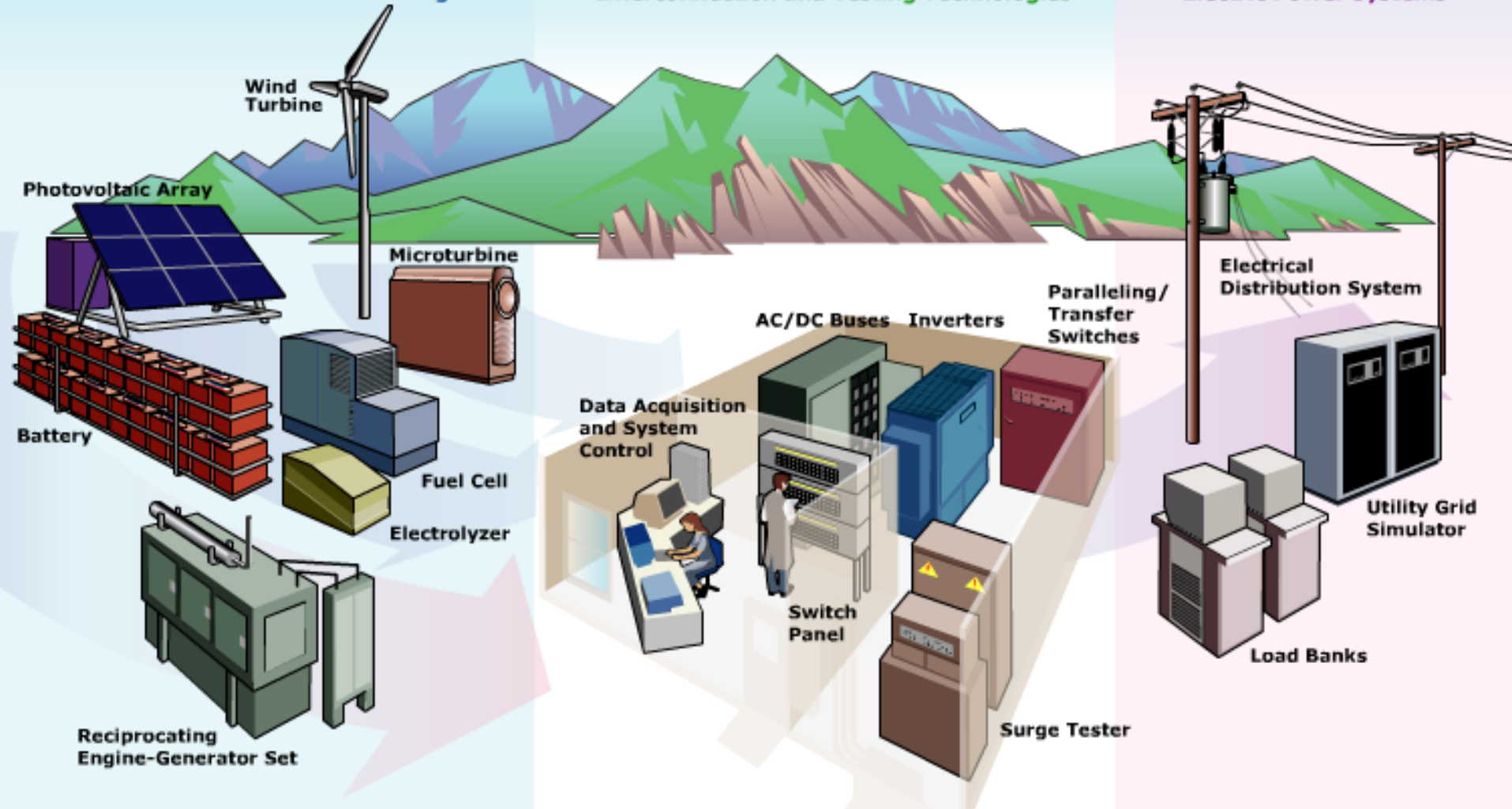
- The Biorefinery – new thermochemical and biochemical conversion technologies
- Solutions to under-utilized waste residues
 - Agriculture
 - Forestry
 - Urban
- Advanced agriculture (energy crops) enabled by plant genomics and bioscience

Next Generation Electric Power System: Intelligent, resilient, and self-healing

Distributed Generation and Storage

Interconnection and Testing Technologies

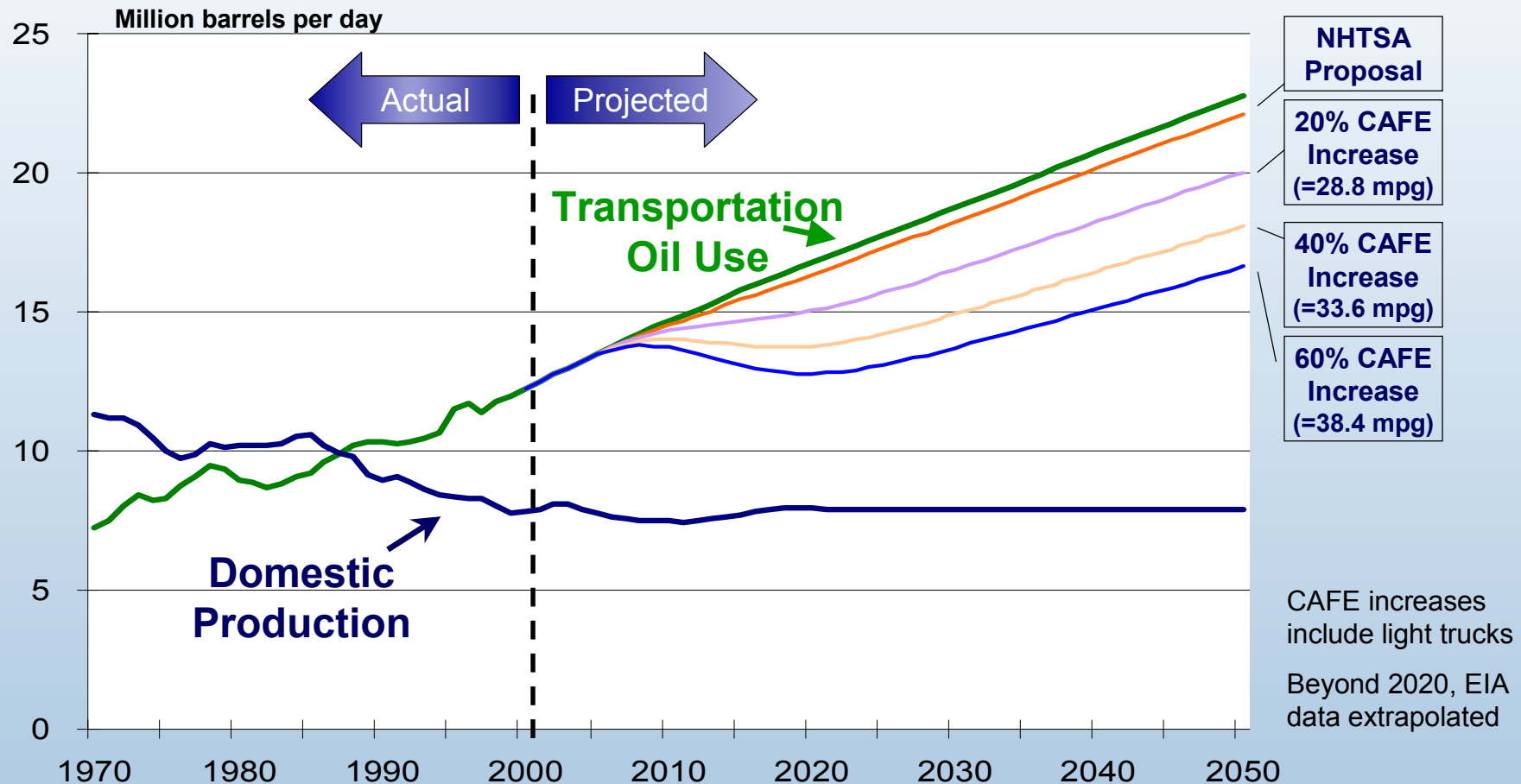
Electric Power Systems



Research Focus in Buildings

- Zero-energy homes
- High-performance commercial buildings
- Emerging technologies
 - Solid state lighting, prismatic lenses
 - Building envelope research
 - Advanced windows

Increasing Fuel Economy Helps for Next 2 Decades, But is Not Enough to Offset Long-Term Growth



DOE is promoting hybrid vehicles in near-term (\$90M annually for cost reduction of hybrid components) and hydrogen research for long-term.

FreedomCAR and Fuel Partnership



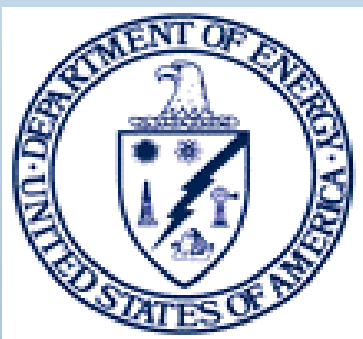
ChevronTexaco

ConocoPhillips

ExxonMobil



DAIMLERCHRYSLER



New Energy Company/DOE Technical Teams

- Production
- Delivery
- Fuel Pathway Integration

New Joint Auto/Energy/DOE Technical Teams

- Codes and Standards
- Storage

Research Focus in Transportation FreedomCAR



- Transition – hybrids, then fuel cells
- Systems modeling (digital functional vehicle)
- Cleaner lubricants, improved fuels
- More efficient/comfortable cabin environment

President's Hydrogen Initiative

NREL Focus

- Renewable H₂ Production
- Carbon-based Hydrogen Storage
- Infrastructure/Codes and Standards
- Fuel Cell Integration (mobile and stationary)
- Systems Integration & Analysis (production through end use)

The Goal:

- Electricity and hydrogen are produced from abundant, domestic supplies of primary energy resources with zero or near-zero emissions.
 - Renewables including wind, solar, hydro, geothermal, biomass;
 - Nuclear fission and fusion;
 - Fossil fuels with carbon sequestration.



Commercial Growth Requires Addressing Market Demands

- Cost of renewable energy must be competitive.
- Capital must be mobilized.
- Public policy measures must value externalities and be predictable.
- Institutional infrastructure must be developed in emerging economies.

Technologies

- High technology
- Mass production



Policies

- Incentives & mandates

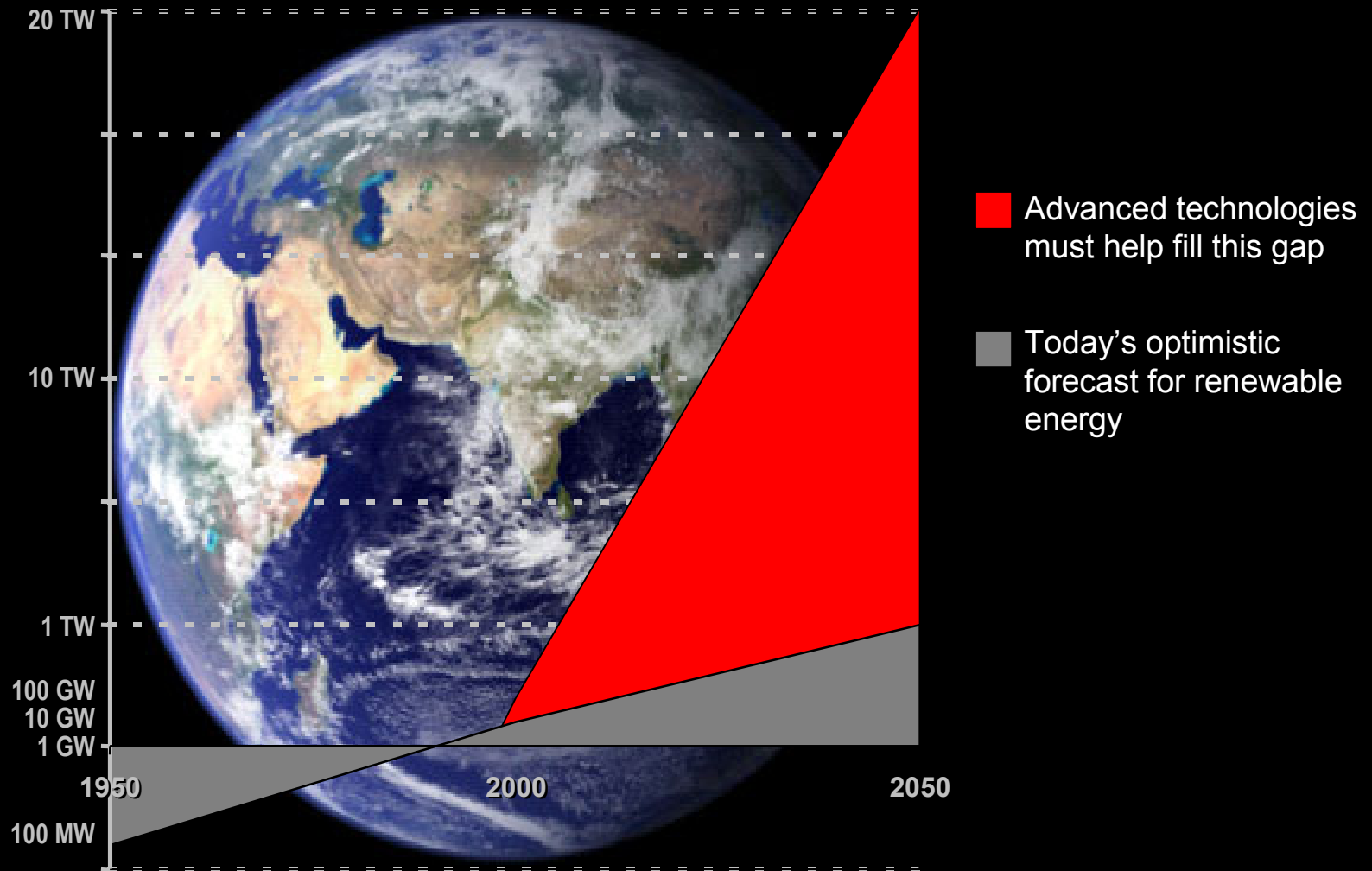


Markets

- Conventional energy prices
- Green markets



Magnitude of Challenge Requires Global Action and a Change in Trajectory



The U.S. Department of Energy's National Renewable Energy Laboratory



www.nrel.gov
Golden, Colorado